Quantum rod light emitting diodes for future display and light emitting applications

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Abstract

The quantum dot in rod shape, Quantum nanorods (QRs) are emerging materials for optoelectronic applications, which offers polarized emission that brings various benefits in terms high brightness, color purity, high optical outcoupling efficiency and better stability in solid form. Herein, we reported with detailed analysis of the synthesis, optical, electrical characteristics of solution processed CdSe/CdS, Cdse/ZnxCd1-x/ZnS, and Cdse/ZnxCd1-xS (core/shell) RGB QRs and, this is the first report to demonstrate the red, green, and blue electroluminescent QR based light emitting diodes (LEDs). The CdSe/CdS, and Cdse/ZnxCd1-x/ZnS QR's are used for red and green, blue emissive layers and control charge injection balance into the QRs emissive layers is enhanced by hosting a poly (methyl methacrylate) (PMMA) layer among emissive layers and oxide electron transport layer. Where the PMMA insulating layer obstruct the excessive electron flux and thus promotes balanced charge injection within QR layers. The fabricated QRLED without a PMMA layer, exhibits with a peak external quantum efficiency (EQE) of 7.01%, 5.61% and 0.80 % and maximum brightness of 2670.10 cd/m2, 11892.84 cd/m2 and 310.20 cd/m2 for RGB colors, respectively. By inserting an optimized 0.8 mg/ml thick PMMA layer, the peak EQE of the device are rises to 9.45%, (red), 6.80 % (green) and 1.35% (blue) QRLED's and efficiency roll-off is less than 50% at maximum current density. This enriched device performance achieved by accommodating a thin PMMA layer into the device and is responsible to maintain the balanced charge injection and preserve the high electroluminescence properties of the QRs. This kind of new RGB QRLEDs opens avenue to improve the device efficiency and stability further to use in real device applications.

Results

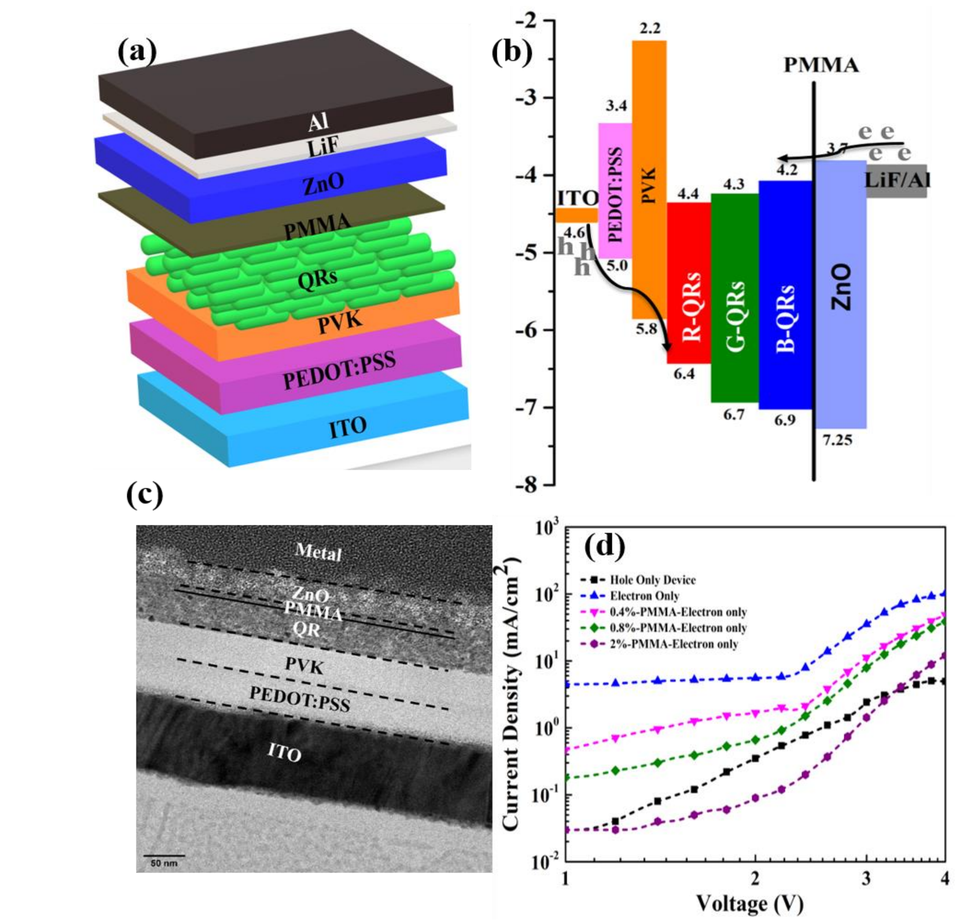

Figure 1. (a) Schematic structure of the multilayered QRLED, (b) energ y level alignment of the QRLED, (c) cross-sectional HR-TEM image of the red-QRLED architecture and (d) is the current density-voltage chara cteristics of the electron (ITO/ZnO/PMMA/QRs/PMMA/ZnO/LiF/Al) a nd hole only (ITO/PEDOT:PSS/PVK/QRs/PVK/LiF/Al) single carrier d evices with CdSe/CdS red QRs.

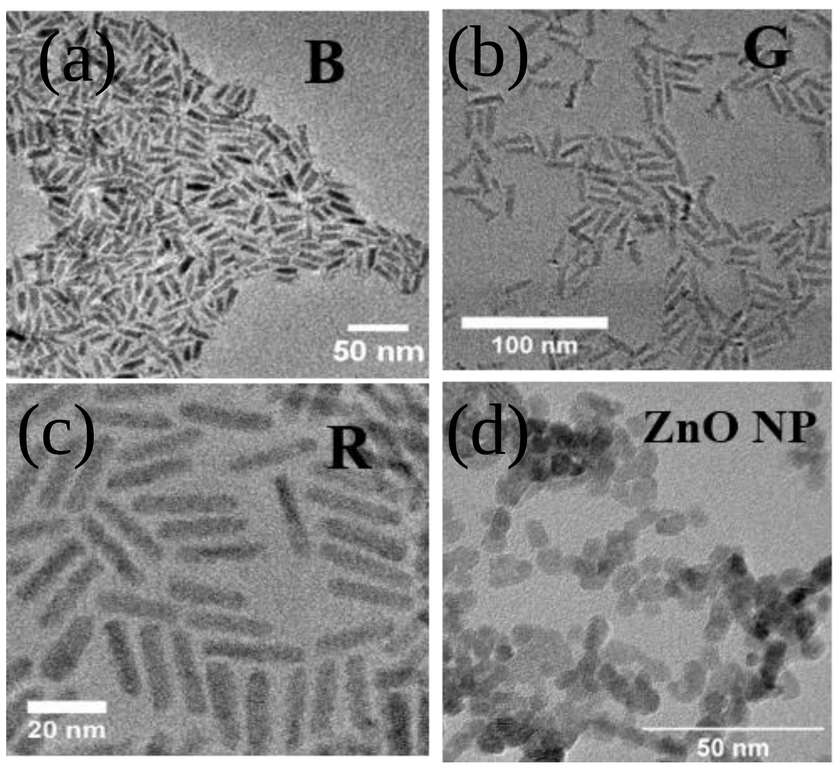

Figure: 2. HRTEM images (a) blue QRs, (b) green QRs, (c) red QRs and (d) ZnO NP, respectively.

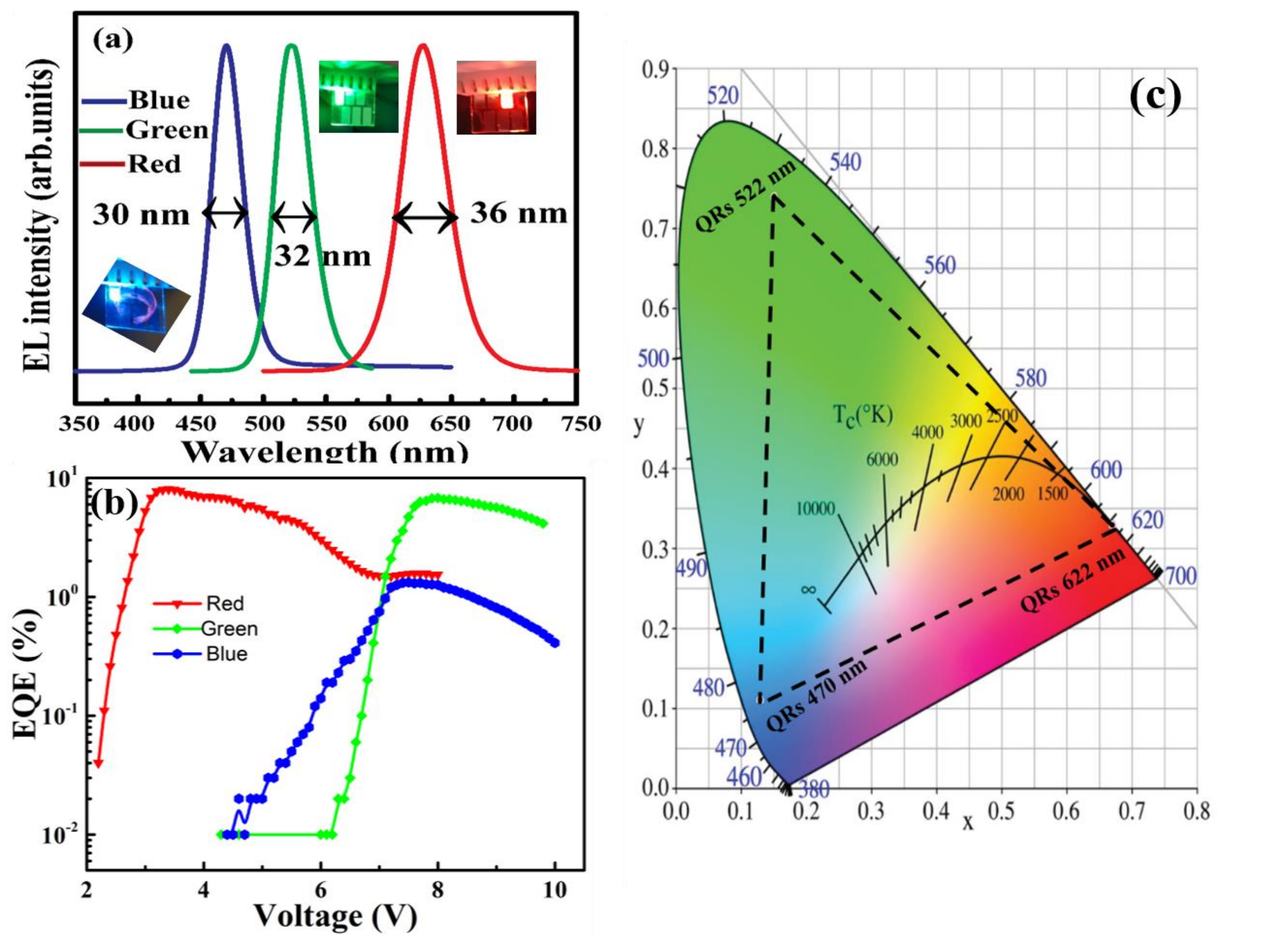

Figure 3: (a) normalized EL spectra of BGR-QRLEDs, (b) EQE-voltage of the RGB-QRLEDs with a PM MA layer and (c) CIE color coordinates corresponding to our GBR-QRLEDs represented with dotted

Conclusion

The solution processed hybrid QRLED device structure, where the synthesized RGB QRs were sandwiched between hole transport layer (PVK) and electron transport layer (ZnO), further we optimize the device structure through PMMA layer insert in-between QRs to ZnO interface. The fabricated QRLEDs without PMMA is exhibit the maximum EQE and brightness are reaching 7 % and 2670 cd/m2 for red, 5.6 % and 11890 cd/m2 for green and 0.82 % and 310 cd/m2 for blue, QRLEDs. Through further tuning the device structure with an optimized 0.8 % PMMA, we elevated the peak EQE up to 9.4 %, 6.7% and 1.3 % together with a with good brightness and narrowed FWHM in the range of 30-36 nm for RGB-QRLEDs, respectively. The roll-off efficiency of the devices with a PMMA was improved more than 60 % compared with the device without PMMA from RGB-QRLEDs. Further can improves the device performance more, due to the double out coupling efficiency has a potential to over the QDLEDs performance, through by improving the PLQY of QRs and device optimization methods. The demonstrated solution processed RGB-QRLEDs results implying that the newly synthesized RGB-QRs materials brings a new feature with unique properties has a strong potential in achieving high EQE and high brightness for future lightning and display applications.

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References

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